JC08 Rec'd PCT/PTO 15 FEB 2001

FORM PTO-1390 REV. 5-93 US DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371**		ATTORNEYS DOCKET NUMBER **P00,1971** U.S.APPLICATION NO. (if known, see 37 CFR 1.5) 09/763047
INTERNATIONAL APPLICATION NO. **PCT/DE99/02484**	INTERNATIONAL FILING DATE 9 August 1999	PRIORITY DATE CLAIMED 17 August 1998

TITLE OF INVENTION
"METHOD FOR ROUTING CONNECTIONS IN AN ATM NETWORK"

APPLICANT(S) FOR DO/EO/US
Josef RAMMER, Marco CONTE, Gerhard FISCHER, Luigi BELLA and Ferial CHUMMUN

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay.
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).)
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C.371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98; **(PTO 1449, Prior Art, Search Report).**
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included. **(SEE ATTACHED ENVELOPE)**
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☒ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:
    a. ☒ Request for Approval of Drawing Changes
    b. ☒ **EXPRESS MAIL #EL 655300978US, dated February 15, 2001.**

U.S. APPLICATION NO. (if known, see 37 C.F.R. 1.5) 09/763047	INTERNATIONAL APPLICATION NO. PCT/DE99/02484	ATTORNEY'S DOCKET NUMBER P00,1971

17. ☒ The following fees are submitted:

		CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5): Search Report has been prepared by the EPO or JPO .... $860.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) . . $700.00 No international preliminary examination fee paid to USPTO (37 C.F.R. 1.482) but international search fee paid to USPTO (37 C.F.R. 1.445(a)(2) .... $770.00 Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2) paid to USPTO .... $1040.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) .... $ 96.00			
ENTER APPROPRIATE BASIC FEE AMOUNT =		$ 860.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).		$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	13 - 20 =		X $ 18.00	$ .00	
Independent Claims	1 - 3 =	1	X $ 80.00	$	
Multiple Dependent Claims			$270.00 +	$	
TOTAL OF ABOVE CALCULATIONS =				$ 860.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 C.F.R. 1.9, 1.27, 1.28)				$	
SUBTOTAL =				$ 860.00	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 860.00	
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). $40.00 per property +					
TOTAL FEES ENCLOSED =				$ 860.00	
				Amount to be refunded	$
				charged	$

a. ☒ A check in the amount of $ 860.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. ___________ in the amount of $ _______ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 501519. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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NAME

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Registration Number

IN THE UNITED STATES ELECTED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY-CHAPTER II

"**PRELIMINARY AMENDMENT**"

APPLICANT: Josef RAMMER et al.

SERIAL NO.: EXAMINER:

FILING DATE: ART UNIT:

INTERNATIONAL APPLICATION NO.: PCT/DE99/02484

INTERNATIONAL FILING DATE: 9 August 1999

INVENTION: METHOD FOR ROUTING CONNECTIONS IN AN ATM NETWORK

Hon. Assistant Commissioner for Patents
Box PCT
Washington D.C. 20231

SIR:

Amend the above-identified international application before entry into the national stage before the U.S. Patent & Trademark Office under 35 U.S.C. §371 as follows:

IN THE SPECIFICATION

At the top of each page, please delete "GR 98 P 2350".

On page 1, before the title, delete "Description";

before the title, insert --

SPECIFICATION

TITLE--;

after the title, insert --

BACKGROUND OF THE INVENTION

Field of the Invention--; and

after line 12, insert --

Description of the Related Art--.

On page 3, after line 13, insert --

SUMMARY OF THE INVENTION--.

On page 5, in line 23, delete "The said measure" and insert --This--; in line 28, delete "In this case" and insert --Accordingly--; and delete lines 36 and 37.

On page 5a, delete lines 1 and 2.

On page 6, before line 1, insert --

BRIEF DESCRIPTION OF THE DRAWINGS--; and

after line 4, insert --

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS--.

On page 7, in line 13, delete "which are available"; delete line 14; and in line 15, delete "www.atmforum.com,.

On page 8, delete line 11, and insert --In another embodiment, the invention--; and in line 12, delete "in the following text, in contrast,".

On page 9, in line 9, delete "One" and insert --In another embodiment, one--.

On page 15, after line 3, add the following new paragraph --

Although other modifications and changes may be suggested by those skilled in the art, it is the intention of the inventors to embody within the patent warranted hereon all changes and modifications as reasonably and properly come within the scope of their contribution to the art.--.

IN THE DRAWINGS

Please amend the drawings in accordance with the request for approval of drawing changes attached hereto.

IN THE CLAIMS

Please cancel all claims without prejudice and add new claims 13-25 as follows:

13. A method for routing connections in an ATM network having a plurality of nodes connected by respective transmission paths, each node having a routing processor associated therewith, and a routing system in communication with said routing processor, said method comprising the steps of:

transmitting an ATM connection request to one of said nodes including a selected route for routing said request along at least one of said transmission paths, and a cell rate requirement;

checking said request in the routing processor associated with said one of said nodes to determine if said selected route is available;

if said selected route is not available, signaling an overflow message from the routing processor associated with said one of said nodes to said routing system, said over flow message including said cell rate requirement and a current utilization level of said selected route;

in said routing system defining an alternative route with an algorithm employing said cell requirement, said utilization level and a frequency of

overflow messages for requests at other of said nodes; and

communicating said alternative route from said routing system to said routing processor associated with said one of said nodes, and via said routing processor, routing said request from said one of said nodes on said alternative route.

14. A method according to claim 13, further comprising;

at least one of producing and updating a histogram of overflow events relating to said associated cell rate requirement from said overflow events, and

calculating a value of said present utilization level for a relevant transmission path from said histogram via a known and predetermined probability distribution of cell rate values of all connection attempts.

15. A method according to claim 14, further comprising the step of: producing said histograms in a regional routing controller for all transmission paths in a region.

16. A method according to claim 15, further comprising the step of: exchanging said histograms between regional routing controllers at predetermined times.

17. A method according to claim 13, further comprising the steps of: defining said alternative route in a regional routing controller; and transmitting said alternative route to one of a source node and a routing processor associated with said source node.

18. A method according to claim 13, wherein said overflow message further contains a parameter relating to nature of a requested connection.

19. A method according to claim 18, wherein said overflow message contains a quality parameter.

20. A method according to claim 14, wherein depending on requirements of said routing system only a specific proportion of said overflow events is signaled to said routing system.

21. A method according to claim 13, further comprising the step of: further emitting status messages to the routing system at predetermined times.

22. A method according to claim 21, wherein said status messages include actual utilization level of the transmission paths.

23. A method according to claim 13, further comprising the step of: producing said negative decision message for those connection attempts with cell rate requests capable of being satisfied at a route utilization level, said route utilization level capable of being predetermined.

24. A method according to claim 23, further comprising the step of: producing said negative decision message for a cell rate request in accordance with a predetermined pattern, said cell rate request capable of being intrinsically satisfied.

25. A method according to claim 24, wherein said predetermined pattern is a pseudo-random pattern.

IN THE ABSTRACT

In line 1, change "Abstract" to --Abstract of the Disclosure--;

delete line 3, "Method for routing connections in an ATM network";

in line 7, delete "(K_i)";

in line 8, delete "(Ui_j)";

in line 9, delete "(RP_i)";

in line 11, delete "(RSY)";

in line 14, delete "(RP_i)";

in line 18, delete "(RSY)"; and

in line 26, delete "Figure 1".

REMARKS

The foregoing amendments to the specification and claims under Article 41 of the Patent Cooperation Treaty place the application into a form for prosecution before the U.S. Patent and Trademark Office under 35 U.S.C. §371. Accordingly, entry of these amendments before examination on the merits is hereby requested.

Respectfully submitted,

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09/763047
JC03 Rec'd PCT/PTO 15 FEB 2001

IN THE UNITED STATES ELECTED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY-CHAPTER II

"REQUEST FOR APPROVAL OF DRAWING CHANGES"

APPLICANT: Josef RAMMER et al.

SERIAL NO.: EXAMINER:

FILING DATE: ART UNIT:

INTERNATIONAL APPLICATION NO.: PCT/DE99/02484

INTERNATIONAL FILING DATE: 9 August 1999

INVENTION: METHOD FOR ROUTING CONNECTIONS IN AN ATM NETWORK

Hon. Assistant Commissioner for Patents
Box PCT
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SIR:

Applicants herewith request approval of the drawing changes in the Figures 1 and 2, as shown on the drawing copy marked in red attached hereto.

Respectfully submitted,

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09/763047

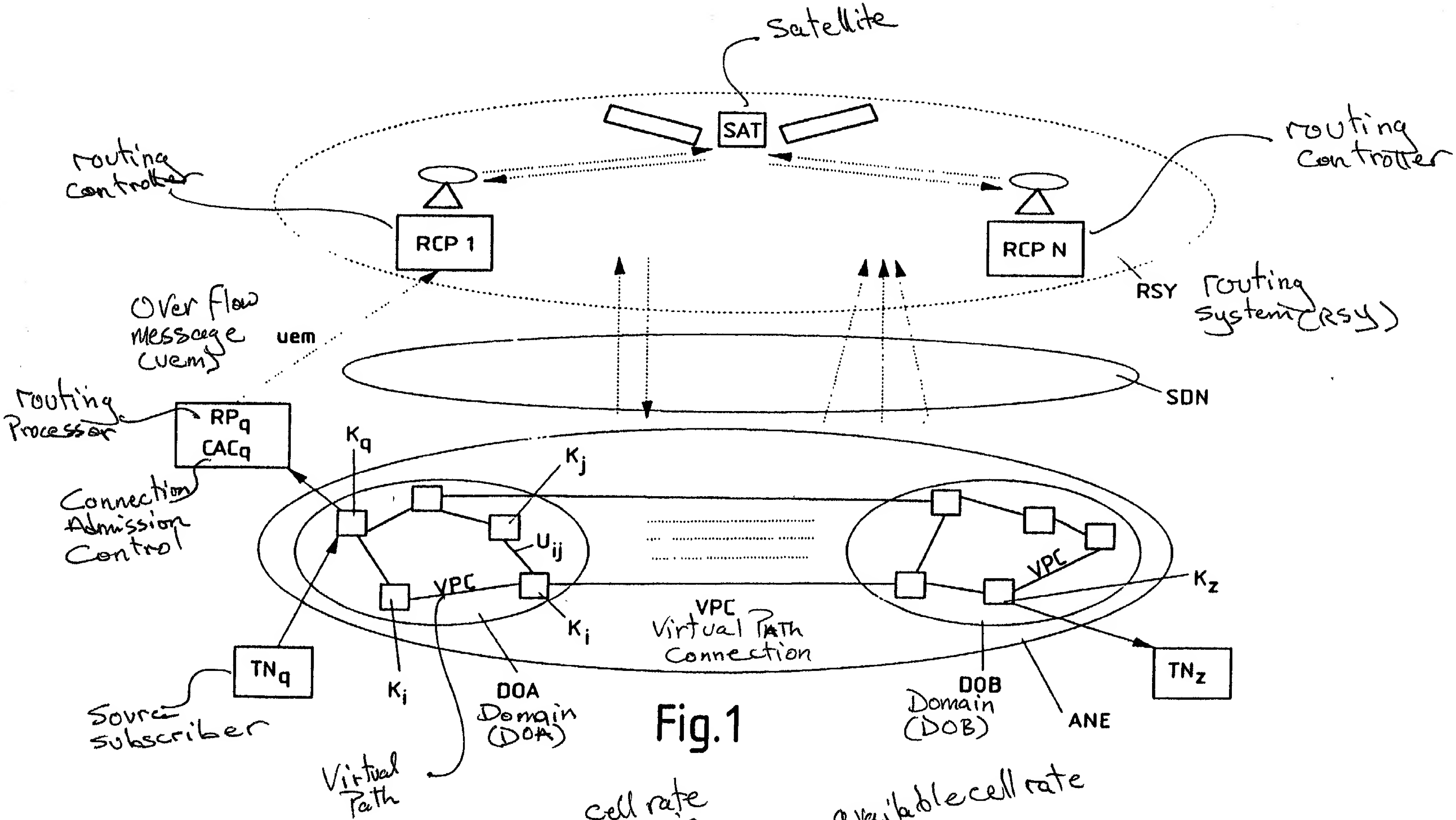


Fig.1

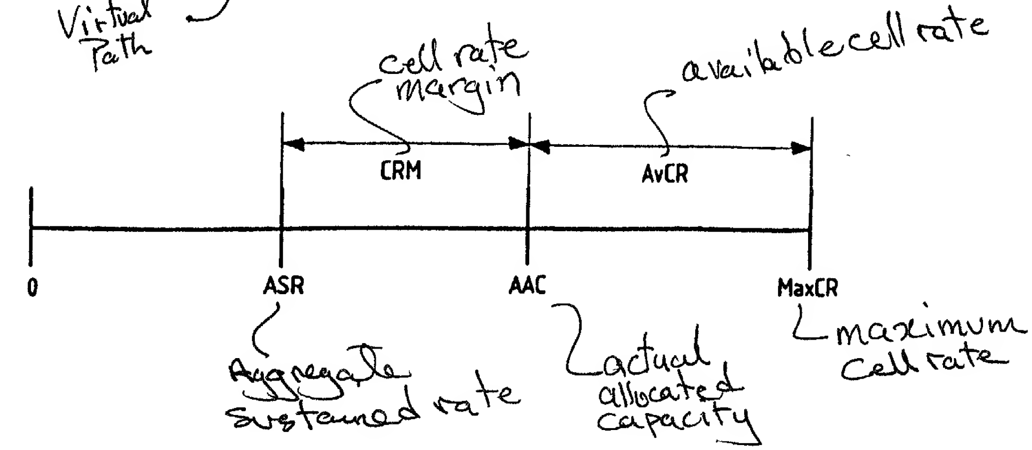


Fig.2

Description

Method for routing connections in an ATM network

The invention relates to a method for routing connections in a connection-oriented communications network which contains switching nodes and transmission paths between the nodes, with the nodes having associated routing processors and an alternative route being defined with the aid of a routing algorithm in a routing system as a function of the frequency of the blocking events on the transmission paths.

A method of this type, but for a line-switching network, is described in AT 401 702 B from the same applicant. This document also generally describes dynamic routing methods and the disadvantages associated with them, in particular the relatively high complexity, and, as a solution, proposes that blockages on direct transmission paths be detected, and that the occupation level of the transmission paths be determined from the frequency of these blockages. The document also explains that the probability of the occupancy of transmission paths can be calculated off-line from destination traffic data by using a routing management processor and that, for example, the "forward-looking routing" algorithm according to K. R. Krishnan, T. J. Ott in Forward-Looking Routing, A New State-Dependent Routing Scheme, Tele-traffic Science for New Cost-Effective Systems, Networks and Services, ITC-12 (1989) is suitable for such a calculation.

However, the method according to AT 401 702 B takes account only of connections having the same and a constant bandwidth, as are typical for conventional telephone connections where, for example, the bandwidth of a connection is 64 kbit/s. In contrast, a constant bit rate is exceptional for ATM networks (Asynchronous

Transfer Mode) since connections can be produced with a different bandwidth, which varies over time,

depending on the subscribers' connection attempts. Apart from the desired bandwidth, for example 1 Mbit/s, connection requests from subscribers often also contain information relating to the required connection quality.

ATM is a network technology which is suitable for transporting any desired digital information, such as pure data, speech and video data, etc, and with the designation ATM occasionally being used as a synonym for B-ISDN (= Broadband Integrated Services Digital Network). A characteristic feature of ATM is structuring in cells of the same length. The information to be transmitted is split into ATM cells, namely into packets of 53 bytes which carry a cell header of 5 bytes and a payload of 48 bytes. In this case, the header information identifies a specific virtual connection. In contrast to a TDMA method, for example, in which timeslots are associated with various types of data traffic in advance, the data traffic arriving at an ATM interface is segmented into said 53-byte cells, and these cells are passed on sequentially, in the same way as they were produced. Further details relating to ATM can be found in the literature. By way of example, the following may be cited here: "ATM-Networks, Concepts, Protocols and Applications", by Händel, Huber and Schröder, Verlag Addison-Wesley-Longman, 2nd edition 1994 (ISBN 0-201-42274-3).

Within the framework of so-called PNNI specifications (PNNI = Private Network Node Interface, ATM Forum af-pnni-0055.000: PNNI V1.0; af-pnni-0066.000: PNNI V1.0 Addendum), the ATM forum had proposed methods for ATM networks which provide the respectively most recently measured traffic levels in the ATM nodes for a routing algorithm. In this case, all the ATM nodes must measure their own traffic levels at the times defined by the algorithm and pass them on to all the other nodes within a group using a so-called "flooding" algorithm. However, particularly

in high-load situations, this results in the network resources being particularly heavily loaded by the data measurement and distribution algorithm, as a result of which this method, which is actually intended to solve the problem of searching for good transmission paths when the traffic load is high, itself results in a considerable additional load on the network which is undesirable, particularly when the traffic load is high. In this context, reference may be made to U. Gremmelmaier, J. Püschner, M. Winter and P. Jocher, "Performance Evaluation of the PNNI Routing Protocol using an Emulation Tool", ISS 97 XVI World Telecom Congress Proceedings, pp 401 - 408.

One object of the invention is to specify a routing method which ensures optimum utilization of the transmission networks in ATM networks.

Against the background of a method of the type mentioned initially, this object is achieved in that, according to the invention, ATM connection requests which arrive in the routing processors from subscribers are checked for the selected route, a negative decision is signaled if this route is not available for a specific connection request and an overflow message is emitted to the routing system, which overflow message also contains the associated cell rate requirement of the subscriber and the present utilization level of the transmission path, and the alternative route is defined taking account of the frequency of the overflow messages for specific cell rate requests from other routes.

The invention thus evaluates those connection attempt events for which it has previously not been possible to provide the desired transport capacity on a predetermined transmission path between a source node and destination node, and also supplies the routing system with information relating to the cell rate request from the subscriber and the present utilization

level of the transmission path, thus making it possible for the routing system

to determine suitable alternative paths, comprising two or more subsections.

One highly effective variant of the invention provides that a histogram of the overflow events relating to the requested cell rate is produced and/or updated from the overflow events, and a present value of the utilization level of the relevant transmission path is calculated approximately from this histogram with the assistance of a known and predetermined probability distribution of the cell rate values of all the connection attempts. A precondition for this is that the probability distribution of the cell rate requests of the totality of all the connection attempts on the relevant transmission path is constant in the long term or varies predictably with time. The histograms are expediently produced in a regional routing controller for all the transmission paths in a region, since this can be done quickly and with comparatively little effort. The histograms can be exchanged between regional routing controllers at predetermined times in order, in the end, to make this information available to the entire network.

It is furthermore recommended that the alternative route defined in a regional routing controller be transmitted to the source node or to a routing processor associated with it.

In order to improve the accuracy of the calculation of the present utilization levels, it is possible to provide for the overflow message to contain further parameters relating to the nature of the requested connection. In particular, the overflow message may contain a quality parameter.

Since, from experience, overflow events scarcely ever occur one at a time but generally occur in groups, it may in many cases be economic for only a specific proportion of the overflow events

to be signaled to the routing system, depending on the requirements of the routing system.

The accuracy of the calculation can also be improved if, in addition to the overflow messages, status messages are emitted to the routing system at predetermined times. In this case, the status messages may include the actual utilization level of the transmission paths.

It may be advantageous if, beyond a route utilization level which can be predetermined, the negative decision message is also produced for those connection attempts whose cell rate requests could be satisfied at this utilization level. Specifically, if a transmission path continuously or frequently has a specific utilization level and in consequence has only a specific available free transport capacity (AvCR = Available Cell Rate), all the connection attempts with a cell rate greater than this free transport capacity will be rejected, although connection attempts with a low cell rate would always be approved and would once again occupy free transport capacity so that, in the end, connections with a high cell rate could never, or only very rarely, be set up. The said measure leads to a "fairness" which makes it possible to compensate for the imbalance in the preference between connection attempts with a low cell rate and those with a high cell rate.

In this case, the invention can provide that negative decision messages for cell rate requests which can intrinsically be satisfied are produced in accordance with a pattern which can be predetermined, for example a pseudo-random pattern. In this way, the previously mentioned "fairness" can be weighted in a qualified manner. For example, every second or third request with a low cell rate can be rejected.

The invention as well as further advantages will be explained in more detail in the following text

using exemplary embodiments and with reference to the drawing, in which:

Figure 1 shows an ATM transmission network with a routing system, schematically, and

Figure 2 shows the relationship between various cell rates in a diagram.

According to Figure 1, an ATM communications network ANE contains switching nodes K_i, K_j, and transmission paths U_{ij} between the nodes. Transmission paths between nodes are in the form of so-called ATM-VPC or virtual paths (VPC = Virtual Path Connections). These are logic connections between any desired nodes, as well as non-adjacent nodes. A number of nodes may be combined to form a domain, as in Figure 1, which shows two domains DOA, DOB between which there are virtual paths VPC. The nodes K_i have associated routing processors RP_i. These can, inter alia, transmit overflow messages uem to a routing system RSY which, in the present case, has a number of routing controllers RCP 1 ... RCP N, with the individual routing controllers being able to exchange information by satellite SAT. A signaling and/or data network SDN is also located between the ATM network ANE and the routing controllers RCP 1 ... RCP N.

The routing processors RP_i in this exemplary embodiment are represented as dedicated units, in order to simplify the illustration, but it should be mentioned that it is irrelevant where the routing processors are actually located or whether each node has one and only one associated routing processor, and whether the routing processors are "components" of the nodes. The significant factors for the term "routing processor" in the meaning used here are the task and function of the routing processors.

The routing processors RP_i generally also include a connection admission control (CAC_i (CAC = Connection Admission

Control), which in the end provides the decision as to whether the desired transport capacity can be provided on a predetermined transmission path between a source node K_q and a destination node K_z, with a subscriber TN_q being shown as the originating or source subscriber and a subscriber TN_z being shown as the destination subscriber, schematically, in Figure 1.

While a transport connection is being set up in an ATM network, an intelligent routing algorithm should now be able to calculate one or more optimum transport routes by means of network-wide analysis of the free transport capacities of the possible subsections. The specifications from the ATM forum, which are available to all forum members via the http server www.atmforum.com, contain the following definitions of terms and abbreviations relating to cell rates and transport capacities, which will be explained in the following text with reference to Figure 2.

AvCR (Available Cell Rate) is the free transport capacity on a transmission path.

MaxCR (Maximum Cell Rate) is the maximum transport capacity on a transmission path.

SCR (Sustainable Cell Rate) is an upper limit for the mean requested bandwidth of a VBR (Variable Bit Rate) connection. In the case of a CBR (Constant Bit Rate) connection, the SCR is identical to the PCR (Peak Cell Rate). In the case of an ABR (Available Bit Rate) connection, the SCR can be identified with the MCR (Minimum Cell Rate).

ASR (Aggregate Sustained Rate) is the sum of the SCRs (or PCR or MCR as appropriate) of the active connections.

CRM (Cell Rate Margin) is a "Safety margin", which ensures that bit rate fluctuations in active connections do not lead to unacceptable cell losses or delays.

AAC (Actual Allocated Capacity) is the transport capacity of a transmission path which should be regarded as being occupied.

The routing system should now have information with sufficient accuracy about the present utilization level, that is to say the ASR level, of all the transmission paths, in order to allow optimum routes to be selected. However, as has already been mentioned, particularly in large networks, the frequent measurement, collection and distribution of the required data would lead to unreasonably high processing and transmission requirements, for which additional network capacities would be required.

The method according to the invention described in the following text, in contrast, has the object of determining the present ASR values of the critical transmission paths, that is to say the most severely loaded transmission paths, and of making these values available to the routing system, with little effort.

When a connection attempt, originating from a source subscriber TN_q at the node K_q, arrives at the source node, this connection attempt is checked in the node or in an associated routing processor RP_q with regard to the selected route to the predetermined destination node K_z. In this context, it should be noted that each node contains routing tables which include predetermined transmission paths to other nodes.

If the intended route for the specific connection request is now not available, since the requested bandwidth, for example the SCR, cannot be matched to the free transport capacity AvCR still available on this transmission path, a negative decision is signaled, and an overflow message uem is emitted. This so-called overflow event message is notified to the routing system RSY, the essential factor being that this message uem also includes the cell rate request, on which the overflow event is based, from the subscriber T_q, that is to say the requested bandwidth, as well as the present utilization level of the transmission path, that is to say the ASR value.

These values supplied with overflow messages are collected and evaluated in the routing system, as a result of which the routing system can determine suitable alternative paths, which comprise a number of subsections. There are then, of course, a wide range of options for processing the information provided to the routing system in order to determine alternative routes.

One highly effective variant provides for a histogram of the overflow events relating to the requested cell rate to be produced or updated. If, furthermore, a probability distribution of the cell rate values of all the connection attempts is known, a present value for the utilization level, that is to say the ASR value, can be calculated approximately with the assistance of this probability distribution for the relevant transmission path.

It should also be noted that overflow events scarcely ever occur individually but virtually always in groups, that is to say one after the other. Making use of this fact, it is possible, based on a requirement of the routing system RSY, not to signal every overflow event to the routing system but, for example, only every second, third etc, or in entirely general form a specific proportion, which is also known to the routing system since this proportion is predetermined by it, and to use this in the subsequent calculation.

A major aspect of the invention is also based on the overflow events not being evaluated in the nodes K_i of the ATM network but being passed on to regional routing controllers RCP 1 ... RCP N. Each regional routing controller produces the histograms for all the transmission paths in its region and can then approximately estimate the traffic load on these transmission paths. For this regionally known data to be available to the entire network, the regional routing controllers RCP 1 ... RCP N

would have to exchange the data specific for the traffic load with one another at suitable intervals, which can be done, for example, via a separate network SDN (Figure 1) and/or via satellites. A "region" may be understood to be a domain DOA, DOB, as illustrated schematically in Figure 1.

The respective responsible routing controller RCP 1 ... RCP N can process a routing algorithm on the basis of the present traffic load, of which it is aware, on all the transmission paths in the ATM network ANE, and this routing algorithm applies the optimum route for a connection attempt, and this optimum route is then notified to the source node K_q or to a routing processor RP_q associated with it. The invention can, of course, be used in conjunction with distributed routing algorithms in the same way as for centralized or - as just described - regionalized routing algorithms.

In order to improve the accuracy of the calculation, the overflow messages may include further parameters, including parameters relating to the nature of the requested connection. For example, apart from the required bandwidth, that is to say the cell rate, connection requests also include a quality parameter ("Quality of Service") which relates, inter alia, to the maximum cell delay.

A further problem which is specific to ATM networks may occur if a transmission path has a very high utilization level, that is to say ASR value, all the time. In this case, specifically, call requests with a high bandwidth, which exceeds the free transport capacity AvCR (which is actually now small), are always rejected and only connection attempts with a low bandwidth requirement are satisfied. These once again fill up the transmission path and it is obvious that, in the end, connection attempts with a high bandwidth requirement have no chance of being satisfied. For example, in this case, it is possible to introduce a "fairness policy" such that, beyond a transmission path

utilization level which is or can be predetermined, those

connection attempts whose cell rate (bandwidth) requirements would intrinsically be capable of being satisfied at this utilization level are rejected, that is to say a negative decision is made and signaled by the connection admission control CAC. Such negative decision messages may be made in accordance with a pattern which can be predetermined, which may be regular - for example every second or third connection attempt is rejected - or random or pseudo-random - for example a specific percentage of the connection attempts are rejected on average.

Accurate calculation of the ASR value becomes possible if more than just the overflow events are signaled to the routing system. In particular, specific status messages can be sent to the routing system, such as the actual utilization level of the transmission paths at predetermined times. These times may, for example, be those which are provided in the PNNI specifications from the ATM forum for transmission, namely the "flooding" of the so-called "topology state packets" already mentioned in the introduction. The routing system can then also include the status messages in the ASR calculation and, after this, improve the accuracy of the determined values.

Although this does not relate directly to the subject matter of the invention, the possibilities for evaluation of the data supplied to the routing system according to the invention will now be described, in brief. As already mentioned, a histogram is produced, which may also be referred to as an overflow histogram since, for each transmission path, it contains the overflow events as a function of the requested cell rate linked to the overflow event.

On the other hand, the probability distribution of all connection attempts, that is to say their cell rate values, is assumed to be known. This distribution can be determined over relatively long time periods and - if necessary - can, of course, always

be updated once again. On the basis of probability theory, a mathematical relationship can be defined which makes it possible to calculate approximately a present ASR value from the histogram of the overflow events and from the histogram of the known cell rates of the connection attempts. A corresponding calculation method for conventional telephone connections has been defined in "Performance evaluation of dynamic routing based on the use of satellites and intelligent networks", L. Bella, F. Chummun, M. Conte, G. Fischer and J. Rammer, Wireless Networks 4 (1998), p. 167 - 180, J. C. Baltzer AG, Science Publishers.

One option for determining ASR values approximately from the histogram of the overflow values and from a known histogram of the connection attempts is described below.

The connection attempts which occur on the transmission path are subdivided into classes from 1 to K on the basis of their cell rate requirement. The i-th class accordingly requires a cell rate of b_i cells per second ($i = 1, \ldots, K$). In this case, K is the number of possible different cell rate requirements.

The number of overflow messages observed in a time interval T for ATM connection attempts of type i is referred to as n_i in the following text. The K-tuple $(n_1, \ldots, n_K)$ is thus the histogram of overflow messages observed over the time period T. The K-tuple $(p_1, \ldots, p_K)$ denotes the probability distribution, which is assumed to be known, of the cell rates of the connection attempts, where $\sum_i p_i = 1$. The normalized histogram $(p_i, \ldots, p_K)$ may, for example, be determined in advance by measurements, and may be updated if necessary.

The following relationship may be used to determine the request rate λ of call attempts:

$$n_i = \lambda T p_i \; \mathrm{P}\{\text{type } i \text{ attempt is rejected } |\lambda\},$$
$$(i = 1, \ldots, K). \quad (1)$$

P{type i attempt is rejected $|\lambda\}$ =: B_i is the conditional probability for rejection of a connection attempt of type i by the connection admission control CAC, given the rate λ. B_i is governed, inter alia, by the rate λ and by any fairness policy, as has already been explained further above. In general, the following relationship applies: B_i = P{available cell rate < $b_i|\lambda\}$ + P{available cell rate ≥ $b_i|\lambda\}\cdot$P{rejection due to the fairness policy}, where b_i, as defined above, denotes the required cell rate (i=1, ..., K). The rate λ can be determined numerically, using equation (1), from the histogram (n_1, ..., n_K) and the given parameters.

The stationary probability distribution of the occupancy X of the transmission path is calculated from the rate λ, the distribution (p_1, ..., p_K), the mean values of the connection durations τ_1, ..., τ_K, the cell rates b_1, ..., b_K and the capacity C of the transmission path, for example in accordance with J.S. Kaufman, "Blocking in a Shared Resource Environment", IEEE Transactions on Communications, COM-29, No. 10, pp. 1474-1481, October 1981. The probability B_i can be calculated from this distribution, taking into account any "fairness policy".

The time-dependent behavior of the occupancy X can be described, analogously to the abovementioned literature reference "Performance Evaluation ...", by the following differential equation:

$$\frac{dX}{dt} = \sum_{i=1}^{K} \left(\overline{\lambda}_i(\mathrm{X}) - \frac{\overline{m}_i(\mathrm{X})}{\tau_i} \right) b_i \qquad (2)$$

where $\overline{\lambda}_i(\mathrm{X})$ is the rate at which type i connections are set up with an occupancy of X (i = 1, ... K), and m_i(X) is the mean number

of existing type i connections (i = 1, ... K), for an occupancy X.

In order to solve equation (2), the functions $m_i(X)$ may be assumed, approximately, to be as follows: $m_i(X) = X \cdot \frac{m_i}{X_\infty}$, where m_i is the mean number of existing type i connections (i = 1, ... K) in the steady state and can be calculated, for example, in accordance with the already mentioned literature reference "Blocking in a Shared Resource...". The constant X_∞, which may also be referred to as the asymptotic occupancy (see further below, equation (5)), describes the mean occupancy and is given by

$$X_\infty = \lambda \cdot \sum_{i=1}^{K} p_i b_i \tau_i (1 - B_i) \qquad (3)$$

In a similar way to that in the literature reference "Performance Evaluation...", the expression $\sum_{i=1}^{K} \overline{\lambda}_i(X) \cdot b_i$ may likewise be assumed to be a linear function $\overline{\lambda}(X)$ for approximate solution of (2) which satisfies the following conditions:

$$\overline{\lambda}(X_\infty) = \lambda \cdot \sum_{i=1}^{K} p_i b_i (1 - B_i), \qquad (4a)$$

$$\overline{\lambda}(X_s) = \lambda \cdot \sum_{i=1}^{K} p_i b_i \left(1 - B_i(C - X_s + \overline{\lambda}(X_s))\right), \qquad (4b)$$

where C is the capacity of the transmission path. $B_i(C - X_s + \lambda(X_s))$ is the probability of rejection for a type i call when the capacity of the transmission path is reduced to $C - X_s + \overline{\lambda}(X_s)$. Then, $B_i(C) = B_i$. The support point X_s must be chosen appropriately.

After substitution of these linear approximation functions, the differential equation (2) gives a solution for the time-dependent occupancy X(t) in the form:

$$X(t) = X_\infty + (X_0 - X_\infty)\, e^{-\frac{t-t_0}{\tau}}, \qquad (5)$$

where the constant X_0 denotes the occupancy at the time t_0 of the last overflow, and τ denotes a decay time.

Patent Claims

1. A method for routing connections in a connection-oriented communications network which contains switching nodes (K_i) and transmission paths (Ui_j) between the nodes, with the nodes having associated routing processors (RP_i) and an alternative route being defined with the aid of a routing algorithm in a routing system (RSY) as a function of the frequency of the blocking events on the transmission paths,
characterized
in that ATM connection requests which arrive in the routing processors (RP_i) from subscribers are checked for the selected route, a negative decision is signaled if this route is not available for a specific connection request and an overflow message is emitted to the routing system (RSY), which overflow message also contains the associated cell rate requirement of the subscriber and the present utilization level of the transmission path, and the alternative route is defined taking account of the frequency of the overflow messages for specific cell rate requests from other routes.

2. The method as claimed in claim 1,
characterized
in that a histogram of the overflow events relating to the requested cell rate is produced and/or updated from the overflow events, and a present value of the utilization level of the relevant transmission path is calculated approximately from this histogram with the assistance of a known and predetermined probability distribution of the cell rate values of all the connection attempts.

3. The method as claimed in claim 2,
characterized

in that the histograms are produced in a regional routing controller (RCP 1 ... RCP N) for all the transmission paths in a region.

4. The method as claimed in claim 3, characterized in that the histograms are exchanged between regional routing controllers (RCP 1 ... RCP N) at times which can be predetermined.

5. The method as claimed in one of claims 1 to 4, characterized in that the alternative route defined in a regional routing controller (RCP 1 ... RCP N) is transmitted to the source node (K_q) or to a routing processor (RP_q) associated with it.

6. The method as claimed in one of claims 1 to 5, characterized in that the overflow message contains further parameters relating to the nature of the requested connection.

7. The method as claimed in claim 6, characterized in that the overflow message contains a quality parameter.

8. The method as claimed in one of claims 1 to 7, characterized in that only a specific proportion of the overflow events is signaled to the routing system, depending on requirements of the routing system (RSY).

9. The method as claimed in one of claims 1 to 8, characterized in that, in addition to the overflow messages, status messages are emitted to the routing system at predetermined times.

10. The method as claimed in claim 9, characterized in that the status messages include the actual utilization level of the transmission paths.

11. The method as claimed in one of claims 1 to 10, characterized in that, beyond a route utilization level which can be predetermined, the negative decision message is also produced for those connection attempts whose cell rate requests could be satisfied at this utilization level.

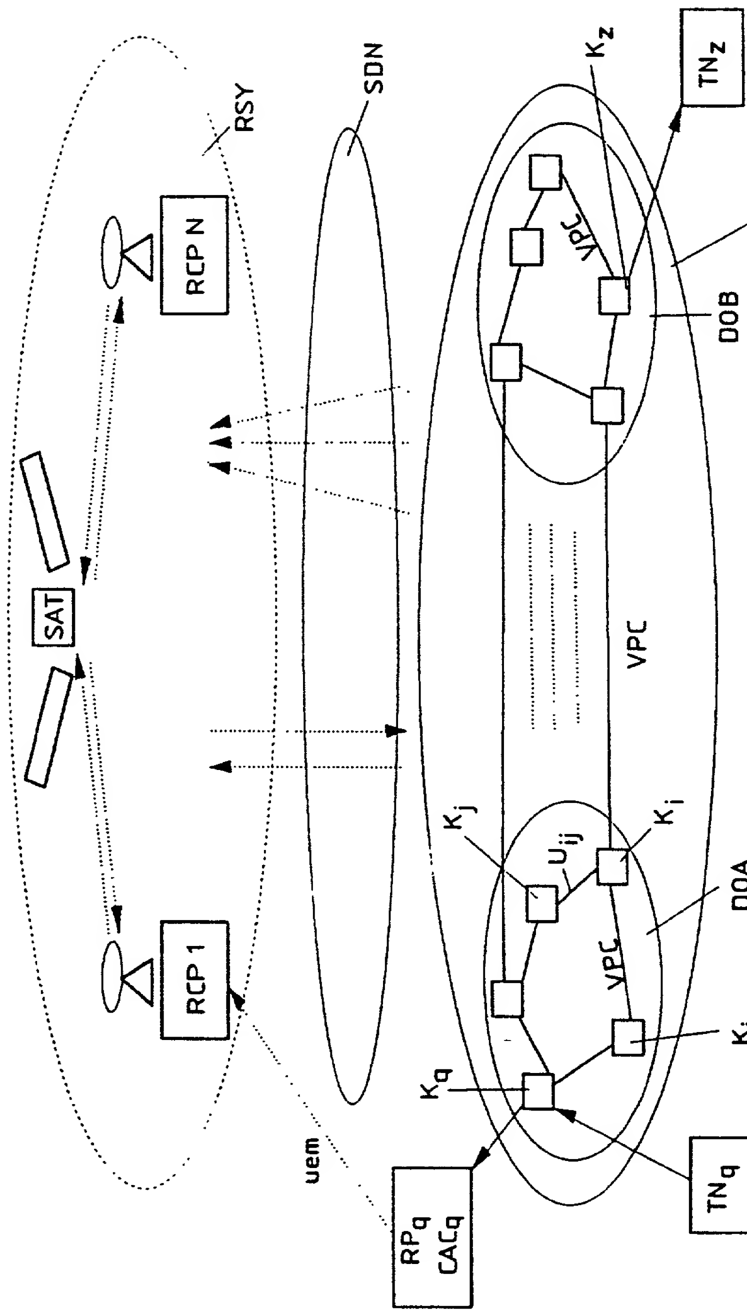
12. The method as claimed in claim 11, characterized in that negative decision messages for cell rate requests which can intrinsically be satisfied are produced in accordance with a pattern which can be predetermined, for example a pseudo-random pattern.

Abstract

Method for routing connections in an ATM network

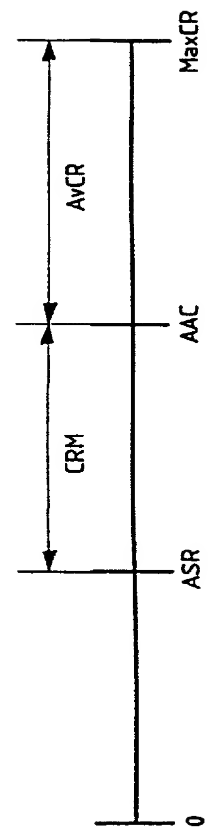
A method for routing connections in a connection-oriented communications network which contains switching nodes (K_i) and transmission paths (Ui_j) between the nodes, in which the nodes have associated routing processors (RP_i) and an alternative route is defined with the aid of a routing algorithm in a routing system (RSY) as a function of the frequency of the blocking events on the transmission paths, ATM connection requests which arrive in the routing processors (RP_i) from subscribers are checked for the selected route, a negative decision is signaled if this route is not available for the specific connection request and an overflow message is emitted to the routing system (RSY), which overflow message also contains the associated cell rate requirement of the subscriber and the present utilization level of the transmission path, and the alternative route is defined taking account of the frequency of the overflow messages for specific cell rate requests from other routes.

Figure 1



RSY
SDN
RCP N
RCP 1
SAT
K_z
TN_z
VPC
ANE
DOB
VPC
K_j
U_ij
K_i
DOA
VPC
K_i
K_q
uem
RP_q
CAC_q
TN_q

Fig.1



AvCR
CRM
MaxCR
AAC
ASR
0

Fig.2

09/763047
JC03 Rec'd PCT/PTO 15 FEB 2001

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"CHANGE OF ADDRESS OF APPLICANTS' REPRESENTATIVE"

APPLICANT: Josef RAMMER et al.

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INVENTION: METHOD FOR ROUTING CONNECTIONS IN AN ATM NETWORK

Hon. Assistant Commissioner for Patents
Washington, D.C. 20231

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Declaration and Power of Attorney For Patent Application
Erklärung Für Patentanmeldungen Mit Vollmacht
German Language Declaration

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Verfahren zum Routen von Verbindungen in einem ATM-Netz

deren Beschreibung

(zutreffendes ankreuzen)

☒ hier beigefügt ist.

☐ am ____________________ als PCT internationale Anmeldung
PCT Anmeldungsnummer ____________________
Eingereicht wurde und am ____________________
Abgeändert wurde (falls tatsächlich abgeändert).

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As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

____
____

the specification of which

(check one)

☐ is attached hereto.

☐ was filed on ____________________ as PCT international application
PCT Application No. ____________________
and was amended on ____________________
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

German Language Declaration

Prior foreign appplications
Priorität beansprucht

Priority Claimed

19837243.4	Germany	17. August 1998	☒ Yes / Ja	☐ No / Nein
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)		
			☐ Yes / Ja	☐ No / Nein
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)		
			☐ Yes / Ja	☐ No / Nein
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(Application Serial No.) (Anmeldeseriennummer)	(Filing Date) (Anmeldedatum)	(Status) (patentiert, anhängig, aufgegeben)	(Status) (patented, pending, abandoned)
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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

And I hereby appoint

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